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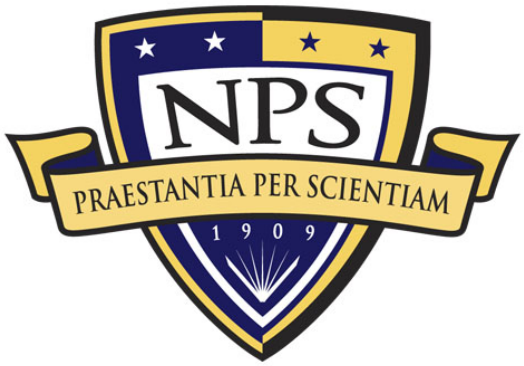

NAVAL POSTGRADUATE SCHOOL

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EVALUATION OF JSAF EM PROPAGATION PREDICTION METHODS FOR NAVY CONTINUOUS TRAINING ENVIRONMENT / FLEET SYNTHETIC TRAINING, RESULTS AND RECOMMENDATIONS: PART IV– JSAF POTENTIAL IMPROVEMENTS COST/BENEFIT ANALYSIS

by

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In previous reports, the authors suggested several potential changes that would improve the realism and accuracy of JSAF range predictions for radar, communications and jamming systems. This report analyzes the estimated benefits and costs of implementing these and other potential changes to JSAF. This information is intended to be used a guide to help JSAF developers and managers prioritize which potential changes would provide the most benefits to JSAF users given limited budgets.

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ABSTRACT

In previous reports, the authors suggested several potential changes that would improve the realism and accuracy of JSAF range predictions for radar, communications and jamming systems. This report analyzes the estimated benefits and costs of implementing these and other potential changes to JSAF. This information is intended to be used a guide to help JSAF developers and managers prioritize which potential changes would provide the most benefits to JSAF users given limited budgets.

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Potential Improvements Cost/Benefit Analysis

A. Introduction

In previous reports, the authors suggested several potential changes that would improve the realism and accuracy of JSAF range predictions for radar, communications and jamming systems. This report analyzes the estimated benefits and costs of implementing these and other potential changes to JSAF. The analysis is summarized in Table 1.

B Analysis

Table 1. contains columns of text showing on the potential change, the expected benefits and a qualitative assessment of the costs. Costs are color-coded as indicated in the first row using the following categories.

1. Development costs – These are the one-time costs to create the model, data set or input method that would replace or augment the current JSAF method. In most cases this would be labor costs for personnel outside NWDC; in some cases it may represent purchase cost of commercial products.
2. Implementation cost – These are the one-time costs incurred during the design, coding, testing and documentation of incorporating the change into JSAF. This would primarily the cost of labor for personnel within NWDC or closely-affiliated contractors.
3. Added Maintenance – These are the extra ongoing costs incurred by NWDC that would be associated with maintaining the change. This includes installing model updates, refreshing data sets and fixing bugs.
4. Execution Time – This represents the increase or decrease in JSAF execution computation time associated with the change.
5. Data Storage – This represents the additional computer storage space incurred by the changes that would be needed.
6. User Interface Complexity – This is the human user "cost" associated with any changes that would need to be made to the JSAF user interface. Added complexity makes JSAF more difficult to understand and run.

Table 1. JSAF Change Cost/Benefit Matrix

Change	Benefits	NWDC Costs (number and color coded)	
		Monetary (mostly labor) 1. Development Costs 2. Implementation Costs 3. Added Maintenance Costs	Non-Monetary (user effects) 4. Execution time 5. Data Storage 6. User Interface Complexity
		7. Other Costs?	
Propagation Models and Sub-Models			
Main Model Replace EREPS (FFACTOR) with APM Propagation Model	Greatly improved accuracy and realism. Currently AREPS (with APM) is the main Navy Operational EM model	1. Minor. APM is in FORTRAN and has been compiled for the LINUX platforms that JSAF uses. JSAF uses mostly C /C++ but should be able to accommodate a compiled FORTRAN module 2. Moderate – may be able to use same "sockets" as current EREPS in JSAF 3. Should be light if APM updates don't require translation. 4. < 1 sec per run for near surface propagation, can be minutes for high frequency, high elevation transmissions. 5. < 1 Mb for executable (output maybe more) 6. Could initially use existing interface, but will need changes as more accurate environmental data are used.	
APM Sub-model Surface Clutter from Ocean Waves	Accounts for increased radar clutter and decreased ranges during rough sea conditions	1. Already in SPAWAR developed APM 2. Moderate – Requires wave info (or winds as proxy) 3. Light 4. Doubles APM execution time 5. None (already in APM) 6. No changes to interface required (but may be beneficial)	
APM Sub-Model Gaseous Absorption	Already included in APM. Generally a relatively small effect.	1. Already in SPAWAR-developed APM 2. No extra since already in APM 3. Light 4. Negligible extra time 5. None (already in APM) 6. May want to include option for doing calculation	
APM Sub-Model Troposcatter	Models troposcatter (scattering off of tropopause) for over-the-horizon VHF and UHF comms.	1. Already in SPAWAR-developed APM 2. In APM for ocean surface cases, not land cases. 3. Light 4. Negligible extra time 5. None (already in APM) 6. Some – need option button	

APM Sub-Model Precipitation Effects	Has significant effect on ranges. Easy to see on radar displays so not as "tricky" as some other effects.	1. SPAWARS SSC developing model , ready in 12-18 months 2. Quite high – would need spatial precip. specification 3. Light 4. Negligible extra time? 5. Would require space for precip. description 6. Some – need option button
Main Model Upgrade Atmospheric Horizontal Variability	Important in coastal regions, atmospheric fronts, over land topography and other high spatial variability situations	1. Already in SPAWAR-developed APM 2. High – Considerable complexity added to JSAF, but should be able to use some of the current assets currently used in JSAF for acoustic modeling, which includes horizontal variations. 3. Light 4. Same execution time as homogeneous cases 5. A little more storage, but probably not significant 6. Significant interface changes required
Main Model Upgrade Land Terrain and Diffraction	Essential for over land predictions. Diffraction allows signals behind topography	1. Already in SPAWAR-developed APM 2. Light - JSAF already has topography 3. Light (unless more data sets added) 4. No significant increase in execution time 5. Depends on resolution needed, could be > 500 Mb for high-resolution data sets 6. No more than above box changes
Terrain Model Upgrade Soil and Vegetation Effects	Improves over land predictions, especially surface wave mode of propagation (lower frequencies)	1. AREPS uses soil type info – fairly crude data base. Difficult to model. No Vegetation in current model 2. Moderate – Need to populate data base 3. Light (unless more data sets added) 4. No significant increase in execution time 5. High - depending on resolution 50 – 500 Mb? 6. Would require option
Main Model HF Propagation	Allows prediction of HF skywave and surface wave propagation for comms and HF over-the-horizon radar	1. AREPS has limited HF model 2. High – needs new module 3. Light 4. Significant increase in execution time 5. Several Mb for ionosphere data base 6. High 7. Would require new JSAF interface

Environmental Models		
Main Model NAVSLaM Evaporation Duct Model	Greatly improved accuracy and realism. Very important for low level propagation over ocean for > 2 GHz signals	1. Already in AREPS 2. Moderate – need to transfer code into JSAF 3. Light (unless more data sets added) 4. Small increase in execution time 5. Negligible 6. Could use existing JSAF interface initially, but should be updated to allow more accurate inputs
Main- Model Refractivity Profile Blending Algorithm	Allows smooth transition from modeled surface layer to upper level obs or predictions. Prevents artifacts associated with "kinks" in M-profile	1. Will be in AREPS in 12-18 months 2. Moderate/High – will need to transfer code 3. Light (unless more data sets added) 4. Small increase in execution time 5. Negligible 6. Could use existing JSAF interface
Environmental Data Sets and Inputs		
Global Evaporation. Duct Climatology	Greatly improved realism for >2 GHz low level signals. Predictions can be keyed to different locations, different large scale patterns (e.g. El Niṅ o) different months and different times of day	1. Development of data base underway 2. Light/Moderate – need input module 3. Light (unless more data sets added) 4. Negligible increase in execution. time 5. Several Mb, depending on areal coverage and resolution 6. Would require new JSAF interface
Global Surface Duct and Surface-Based Duct Climatology	Greatly improved accuracy and realism for all UHF and higher frequencies. Can be keyed to same variability described above	Similar to previous
Global Upper-Level Duct Climatology	Not in current JSAF, important for some air-to-air radar, jamming and comms.	Similar to previous

Real-Time or Short to Medium (1-10 days) forecast Weather Inputs	Would allow simulations of current of near future simulations or realistic "canned" scenarios	1. Significant – would need to access operational data bases 2. Significant – need input modules 3. Depends on operational changes 4. Negligible increase in execution time 5. Not much more storage needed 6. Would require new JSAF interface
System Parameters (analysis not in FY 12 work plan but included for completeness)		
Improved Transmitter Representations	Essential for accurate predictions	1. Data hard to obtain, SPAWARS has a CLASSIFIED data set, but there may be accuracy problems because systems can change and new systems added to Fleet. 2. Significant – need input module 3. Significant – need to update and import new systems data 4. Negligible increase in execution time 5. Not much more storage needed 6. Should be able to use existing JSAF interfaces
Improved Receiver Representations (Communications)	Essential for accurate predictions	Similar to previous
Improved Radar Target Representations	Essential for accurate predictions	Similar to previous

C. Conclusions

This information is intended to be used a guide to help JSAF developers and managers prioritize which potential changes would provide the most benefits to JSAF users given limited budgets. Since the time that this analysis was initially performed in February, 2012, it was decided that the APM model would be incorporated into JSAF. APM and some of the sub-models with it have already passed the development stage and are currently being implemented into JSAF.

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